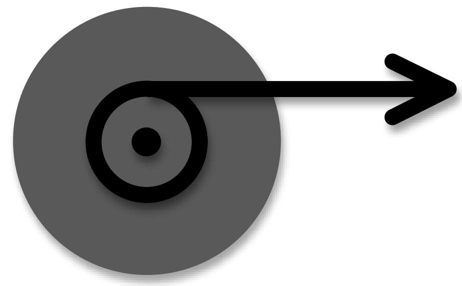
Problem Set #7 due beginning of class, Monday, Nov 10. 80 pts. total

2 pts extra credit per extra person in the group – up to 8 points possible!

3 pts extra credit if you don't use a calculator: if so, write and sign a statement at the top of the problem set: "I [your name] did not use a calculator for any part of this problem set."

#1 You spin up a flywheel by pulling 2 m of string with a tension of 100 N as shown at right. The flywheel is 3 kg flat disk of uniform thickness, is on a frictionless bearing, and has a radius of 30 cm. You have the string wrapped around the hub (or spindle, or pulley) of radius = 10 cm. We will find everything in this problem by starting with energetics!



a) Section 10.3 of your text is about moment of inertia with a nice table showing the moments of inertia for different shapes. Find the moment of inertia of the flat disk flywheel.
b) Find the work I do pulling the string. Where did this work go?
c) Find the final angular velocity, ω.
d) Find the total angle, θ the wheel turns through while I am pulling the string.
e) If $\omega_o = 0$, and assuming there is constant angular acceleration, what is the average ω during the time I'm pulling the string, and how long does it take me to pull the string?
f) What is the angular acceleration α, of the wheel while I am pulling the string?
g) Find the torque, τ, that I must apply to accelerate the wheel as I did?

#2 We repeat the above problem using rotational dynamics! Start with the same problem and assume you have so far only calculated moment of inertia and nothing else.

a) Please find the torque, τ provided by the tension of the string pulling on the pulley.
b) Calculate the angular acceleration, α, of the wheel as you are pulling it. What is necessary to have constant angular acceleration while you are pulling the string?
c) We will learn that rotational work is rotational force times rotational distance, or $W = \tau * \theta$. Is the linear work you did pulling the string = the rotational work done on the wheel?
d) Which way, #1, or #2 do you like best?

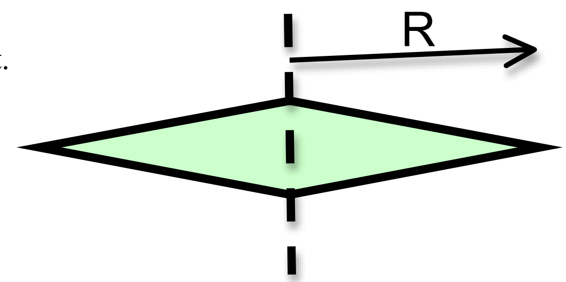
#3 For the problem above, image that we use the same flywheel, but the hub radius is 20 cm; that is the radius of the pulley is doubled. We want to see which other things change and by what factor. Please provide proof for full credit. If r_{pulley} => 2_ r_o, then:

a) How does this change the total angle θ that the wheel turns while I am pulling the string? θ => __ θ_o
again, please show reasoning for each question.
b) How does the final angular speed change? ω => __ ω_o
c) How does the Torque change? τ => __ τ_o
d) How does the angular acceleration change? α => __ α_o
e) How does this change the time it takes to pull the string? t => __ t_o

#4 For problem #1 and #2 above, imagine that you have the *same pulley*, but instead you attach a flywheel that is twice the radius, made of the same metal, of the same thickness, but has a radius of 60 cm. That is, we double the radius of the flywheel: $R_{flywheel}$ => 2_ R_o,

a) How does this change the mass of the flywheel? $m_{flywheel}$ => __ m_o,
again, please show reasoning for each question.
b) How does the moment of inertia of the wheel change? $I_{flywheel}$ => __ I_o,
c) How does this change the torque that I apply by pulling the string? τ => __ τ_o
d) How does the final angular speed change? ω => __ ω_o
e) How does the angular acceleration change? α => __ α_o
f) How does the total angle θ that the wheel turns while I am pulling the string change? θ => __ θ_o
g) How does this change the time it takes to pull the string? t => __ t_o

#5 *(10 pts extra credit)* I invent a new kind of round discus that spins about a vertical axis (dotted line) as shown at right. The object has a thickness of t_o at the axis (at r = 0) and it tapers evenly to a sharp edge at r = R, or $t = t_o(1-r/R)$. If the mass of the discus is M,



a) Judging from moments of inertia of other objects, please guess as best you can what should be the moment of inertia about (dotted line) axis in terms of R, t_o, and M. And support your estimate with reasons.
b) Calculate exactly what the moment of inertia is by integrating over the mass.